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## Response of Underyearling Fluvial Arctic Grayling (*Thymallus arcticus*) to Velocity, Depth, and Overhead Cover in Artificial Enclosures

### Abstract

Underyearling fluvial Arctic grayling (*Thymallus arcticus*) from Montana were tested in artificial enclosures to determine their responses to a range of water velocities and depths and overhead cover. Grayling occupied lower velocity water, shallower depths, and sites under cover in significantly greater proportions than were available. Knowledge of microhabitat feature preferences permits identification of likely rearing habitat and allows more effective sampling of age 0 fish and predictions of relative year class strength.

### Introduction

The natural distribution of the Arctic grayling (*Thymallus arcticus*) in the western contiguous United States was limited to portions of the upper Missouri River drainage in Montana and Yellowstone National Park. Today the only known remaining native population of fluvial Arctic grayling is located in the Big Hole River in Montana. Because it is a declining population with a limited distribution, the fluvial grayling in Montana is designated as a "Species of Special Concern" by the Montana Department of Fish Wildlife and Parks and also by the Endangered Species Committee of the American Fisheries Society (Deacon *et al.* 1979).

Decline of this unique grayling population has stimulated several recent studies. Likness and Gould (1987) investigated the grayling's distribution, macrohabitat, and population characteristics. Sheppard and Oswald (1989) reported on grayling spawning runs and spawning sites. Kaya (1989) examined reotaxis of grayling fry and McMichael (1989) obtained information on the distribution and habitat of yearlings in the upper Big Hole River.

Field conditions can often make precise microhabitat preferences of fish difficult to define. This is true for the grayling inhabiting the stained waters of the Big Hole River where *in situ* observations are impractical. This study was undertaken to obtain information on use of water velocities,

depths, and overhead cover by underyearling fluvial Montana grayling in artificial enclosures.

### Methods

#### Test Enclosures and Underyearlings

Tests were conducted in enclosures in an indoor artificial stream located at the USFWS Bozeman Fish Cultural Development Center. The stream was an elongated doughnut shaped structure (Figure 1). Outside walls and bottom of the stream were constructed of plywood painted with black epoxy; the inside wall was glass to allow viewing.

The artificial stream was supplied with spring water circulated by a 5-speed electric trolling motor. The stream was lighted by overhead fluorescent lighting diffused through translucent white plastic sheets which supplied an average of about 14.9 microeinsteins/m<sup>2</sup>/s (Wang 1989) at the water surface. The glass inner side of the stream was covered with black curtains having viewing ports.

Four similar test enclosures and a holding chamber were established in the artificial stream with screens (Figure 1). Each enclosure was 225 cm long by 61 cm wide by 40 cm deep and contained a riffle-pool-riffle sequence (Figure 2) constructed with 2-3 cm diameter gravel in depths from about 2-35 cm.

Grayling underyearlings tested were from embryos of Big Hole River adults raised at the Bozeman Fish Technology Center. Fish were placed in the holding chamber about 15 hours before being placed in the test enclosures to allow acclimation to temperature and confinement. Fish

<sup>1</sup>Present address: U.S. Forest Service, Payette National Forest, McCall, Idaho 83638

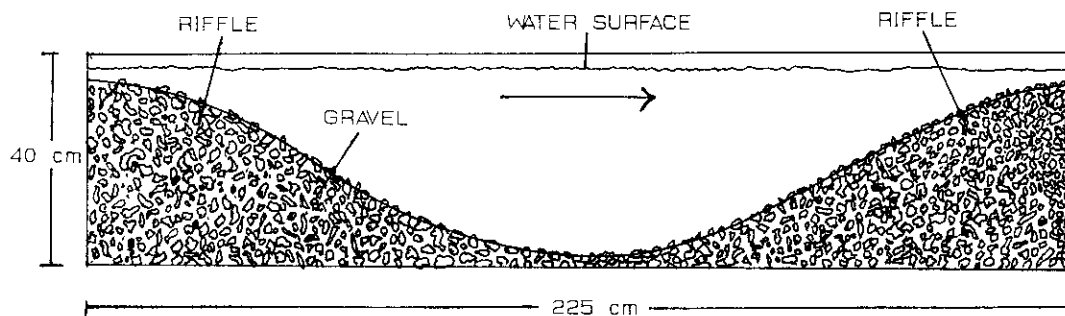


Figure 1. Diagram of artificial stream used in testing underyearling fluvial Montana Arctic grayling.

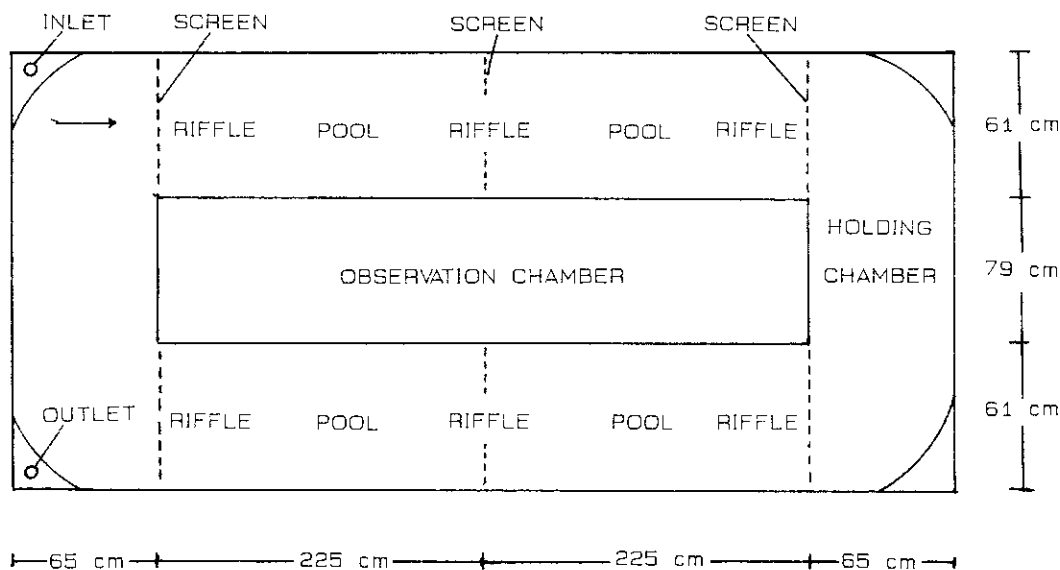


Figure 2. Diagram of enclosure used in tests of underyearling fluvial Montana Arctic grayling.

were fed while in the holding chamber, but not during tests.

### Velocity and Depth Tests

Velocity and depth preference tests were conducted with 27 grayling 60-68 mm in total length from August 10-19, 1988. Fish were tested individually in enclosures 1, 2, and 4 (Figure 1). Beginning 15 minutes after introduction into the test enclosure, the velocity and depth of each fish was measured at 15 minute intervals for 2.0-2.5 hours. Velocity and depth measurements were made with a Montedoro-Whitney model PVM-2A current meter and recorded to the nearest 0.1 cm/s and 0.5 cm depth. Taking measurements disturbed fish for no longer than 30 s.

The velocities and depths available to fish (Table 1) in enclosures 1, 2, and 4 were determined by mapping the enclosures after all of the tests had been completed. Strings were taped across the top of each test enclosure to create a grid of 10 x 10 cm squares. The velocity was measured in 10 cm increments starting at a 5 cm depth. Velocity was measured in the center of each 1000 cm<sup>3</sup> cell. If the remaining depth was less than 10 cm, a final velocity was recorded at one-half the remaining distance. The maximum depth of each cell was recorded as the available depth. The test results from enclosure 3 were not reported because the bottom gravel was inadvertently disturbed prior to measuring enclosure velocities. Temperatures were 16.5-18.0°C during tests.

TABLE 1. Percentages of depth and velocity classes present within the enclosures used for testing underyearling fluvial Arctic grayling.

Parameter	Enclosure number		
	1	2	4
Depth (cm)			
1-9	4.28	9.33	6.63
10-19	18.64	15.03	14.93
20-29	35.54	32.36	47.23
≥ 30	41.52	43.26	31.20
Velocity (m/s)			
0.00-0.09	76.89	71.50	85.60
0.10-0.19	19.52	28.33	14.42
0.20-0.29	3.30	0.18	0.00
≥ 0.30	0.27	0.00	0.00
Total volume (cm <sup>3</sup> )	329,200	275,100	292,000

### Overhead Cover Tests

From August 26-30, 1988, 48 grayling 70-80 mm in total length were used in cover preference tests. Fish were tested individually in all four enclosures (Figure 1); one-half of the length of each enclosure was covered by a sheet of plywood and the other half was uncovered. In successive trials the position of the overhead cover was moved from over one side of the enclosure to the other to equalize the effect of the slight habitat differences between sides. The position of each fish in relation to the overhead cover was observed at 10 minute intervals for 1.5 hours beginning no sooner than 5 minutes after the fish were introduced into the enclosure. Water temperatures were 14.8-16.4°C during tests.

### Statistical Analyses

The respective velocities and depths within each enclosure were grouped into four classes. Each class was constructed to contain about 25 percent of the total volume in its enclosure. The available volumes of these velocities and depth classes were then compared to actual grayling use of these classes by one way chi-square analyses (Lund 1987). Use of cover by grayling was tested with a binomial probability test (Lund 1987).

### Results

The use of velocity classes by Arctic grayling (Table 2) was not proportional to their availabilities in any of the three test enclosures ( $P < 0.01$  for each enclosure). Fish used the lower velocity classes

( $\leq 4$  cm/s) in all enclosures in greater proportions than the volumes of these classes provided.

Grayling use of depth classes (Table 3) also was disproportional to their available volumes in all enclosures ( $P < 0.01$  for each enclosure). Underyearlings made proportionally greater use of the upper 21 cm of the enclosures and less use of depth classes below 30 cm. Furthermore, grayling used areas with overhead cover significantly more often ( $P < 0.01$ ) than areas without cover (Table 4).

TABLE 2. Proportions of velocity groups present in test enclosures and use of velocity groups by underyearling fluvial Arctic grayling.

Variable	Enclosure 1			
	Velocity group (cm/s)	0-4	5-6	7-10
% tank volume	29.2	26.8	24.2	19.8
Number (%) grayling locations	41(46)	25(28)	17(19)	7(8)
Enclosure 2				
Velocity group (cm/s)	0-3	4-6	7-9	10-20
% tank volume	21.2	26.5	23.8	28.5
Number (%) grayling locations	33(37)	25(28)	13(15)	18(20)
Enclosure 4				
Velocity group (cm/s)	0-2	3-4	5-7	8-17
% tank volume	19.6	23.0	29.6	27.8
Number % grayling locations	36(43)	21(25)	13(15)	14(17)

TABLE 3. Proportions of depth groups present in test enclosures and use of depth groups by underyearling fluvial Arctic grayling.

Variable	Enclosure 1			
	Depth group (cm)	0-21	22-27	28-31
% tank volume	25.4	21.9	28.7	24.0
Number (%) grayling locations	45(50)	22(24)	22(24)	1(1)
Enclosure 2				
Depth group (cm)	0-19	20-27	28-31	32-34
% tank volume	24.4	29.3	25.0	21.3
Number (%) grayling locations	47(52)	23(25)	15(17)	5(6)
Enclosure 4				
Depth group (cm)	0-20	21-26	27-29	30-33
% tank volume	25.0	22.9	20.9	31.2
Number % grayling locations	38(42)	25(28)	25(28)	2(2)

TABLE 4. Use of cover by underyearling fluvial Arctic grayling from Montana in 1988. Specimens were 70-80 mm in total length.

Enclosure	Number of fish	Number of observations	
		Under cover	Not under cover
1	12	91	29
2	12	90	30
3	12	86	34
4	12	103	17
Totals	48	370	110

## Discussion

Microhabitat preferences of fish can often be more precisely defined in the laboratory than in the field. This is certainly true for the grayling living in the stained waters of the Big Hole River where *in situ* observations are impractical. About 85 percent of the underyearling grayling were in waters of 0-10 cm/s. This range of velocities is less, and more closely identifies preferred velocities than the reports of juvenile grayling using areas with mean water column velocities of 0.18-0.24 m/s (Elliot 1980, Kreuger 1981, Hubert *et al.*, McMichael 1989).

In 97 percent of our observations, grayling underyearlings were found to be in water depths

of 31 cm or less. This distribution is virtually the same as the depth estimated by the suitability index curve developed by Hubert *et al.* (1985) from field data.

Young grayling are often associated with some type of cover. In this study, they also used overhead cover. In Alaska, young grayling used interstitial spaces and the shadows of boulders as cover (Kreuger 1981), and in the Big Hole River young-of-the-year grayling were often captured within 30 cm of aquatic plants, suggesting vegetation served as cover (McMichael 1989).

The well-being of fluvial grayling (and other populations) is directly dependent on underyearling survival. Evaluations of underyearling abundance can allow managers to assess potential year class strengths more readily and easily than most other methods. Knowledge of the preferred microhabitat permits managers to identify and effectively sample age 0 fish habitat and better predict year class strengths.

## Acknowledgments

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